In common with other books in the series, the details of the experiments, analytical results, etc. are found in the extensive appendices.

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Reuse of Surfactants and Cosolvents for NAPL Remediation

Jeffrey H. Harwell, David A. Sabatini, Chi-Chung Chang, John H. O'Gaver, Thomas J. Simpkin (Authors); Donald F. Lowe, Carroll L. Oubre, C. Herb Ward (Eds.); Lewis Publishers, Boca Raton, FL, 2000, US$ 89.95, 314 pp., ISBN: 1-56670-466-9

This book is best described by the authors who write in the introduction:

> This monograph provides detailed technical information on demonstrations of surfactant recovery arid reuse technologies. Surfactant recovery and reuse includes a group of technologies intended to treat produced fluids and recover surfactant from a surfactant flushing process. The recovered surfactant would then be reused in the flushing processes. Estimated costs for full-scale application and performance of surfactant recovery and reuse technologies are provided. In practice, surfactant recovery and reuse technologies also can be applied to recover cosolvents that are used for soil flushing: however, the emphasis of this monograph is on the demonstration of surfactant recovery and reuse.

A demonstration project it was but a rigorous one being conducted under the Rice University-directed, U.S. Department of Defense-funded, Advanced Applied Technology Demonstration Facility (AATDF) Program for Environmental Remediation Technologies. This book is one of the 10 books that resulted from the 12 funded research demonstration programs.

> In situ surfactant-aided soil flushing is one of the most promising processes for the removal of dense non-aqueous phase liquids (DNAPLs) from aquifers. Surfactant-aided soil flushing is also promising for removing the low volatility, higher molecular weight components of light non-aqueous phase liquids (LNAPLs) from aquifers. Engineering estimates, laboratory-scale tests, full scale simulations, and initial field trials have all indicated that, with proper selection of the surfactant system, use of surfactants could decrease the time required for an aquifer remediation project by an order of magnitude or more.

Since solubilization flushing requires at least 10 pore volumes of surfactant solution to be injected into the contamination zone, recovery and reuse of the surfactant has an impact on the economic feasibility of the remediating large sites.

The objectives of the surfactant recovery program were:

- to evaluate technologies that recover surfactants for reuse in aquifer remediation;
- to demonstrate the most promising treatment system at a field site;
- to perform economic analyses for the pilot-scale and full-scale in situ surfactant-aided soil flushing technologies;

- to evaluate potential performance and applicability of the in situ surfactant-aided soil flushing technologies.

"These activities included preliminary technology evaluation, experimental design, laboratory tests, preliminary economic analysis, recovery processes selection, pilot system design, and field demonstration". Finally, a full-scale engineering design and the evaluation of potential performance and applicability of in situ surfactant-aided soil flushing was performed.

Surfactant recovery and reuse involves two different separation processes: (1) removal of the contaminant from the surfactant stream and (2) removal of the water from the surfactant solution in the preparation for reinjection.

Of the seven removal processes for volatile organic compounds (VOCs) from the surfactant solution and recovery of the surfactant, four were selected for study:

1. air stripping in packed columns;
2. air stripping in hollow fiber membrane columns;
3. vacuum–air stripping in packed columns;
4. liquid–liquid extraction in hollow fiber columns.

A field demonstration was performed at Hill Air Force Base in northern Utah. Both air stripping in a packed column and air stripping in a hollow fiber membrane were tested consecutively on the extracted stream. Ultrafiltration was used to concentrate the surfactant. Ultimately, a full-scale design which included a cost estimate was performed.

"The field demonstrations at Hill AFB OU2 provided valuable information on the potential effectiveness of the surfactant recovery and reuse technologies. A summary of the potential performance of the technology is provided below:

- In the appropriate setting, between 90 and 95% removal of TCE from a surfactant solution should be achievable with a properly designed packed column air stripper. The specific performance is likely to depend on the particular surfactant used, the contaminant of concern, and the concentration of the surfactant.
- Greater than 95% removal may not be economically feasible to achieve from a packed column air stripper in the presence of surfactants. Low effluent concentrations (e.g. less than 1 mg/l) require several repeat treatment passes.
- Special precautions are needed to prevent foaming. These include limiting the volumetric loading rate, appropriate design of the air inlet configuration, appropriate design of the water distribution system and possibly providing provisions to heat the influent.
- In the appropriate setting, between 90 and 95% removal of TCE from a surfactant solution should be achievable with a hollow fiber air stripper. The performance of hollow fiber air strippers appears to be more strongly related to surfactant concentration, so the performance may be decreased at high surfactant concentrations. The performance will also depend on the particular contaminant and the surfactant used.
- Greater than 95% removal may not be economically feasible using a hollow fiber air stripper in the presence of surfactants".

Lacking, the authors note, was a full development of the surfactant recovery and reuse technology. That is an area requiring more work.

As is common in this series, the appendices make up the major fraction (over two-thirds) of the book. They contain the complete details of the research design, results and projections. Especially notable in this series of books is the provision of a hypothetical full-scale design and cost estimate thereof which, in all cases (to the best of my memory), involved the input of consulting environmental engineers.

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